A BIOLOGICAL EVALUATION OF THE LEVEL AND CAUSES OF TREE MORTALITY ON THE SAN BERNARDINO NATIONAL FOREST IN 1976

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The San Bernardino National Forest has the highest visitor use of any National Forest in the United States. Most of the recreation use is concentrated in the pine and mixed conifer forest types, an area of about 100,000 acres. Since the maintenance of a suitable tree cover is crucial to the dominant uses of the Forest, i.e., recreation and watershed, there has been considerable concern over the weakening and killing of trees attributed to a number of agents including bark beetles, flatheaded borers, dwarf mistletoe, annosus root rot and oxidant air pollution. Since the level of tree mortality and the relative importance of the various agents, as causes for the mortality are not known, a three year evaluation was begun in 1976. The data for the evaluation are obtained from a survey done in cooperation with the Forest Insect and Disease Management Staff of the Forest Service, the Environmental Protection Agency and University of California, Berkeley.[1/] This report is based on data from the 1976 survey, the first year of the three year study. A more complete report containing results of the three year study will be written in 1979.

SURVEY DESIGN AND METHODS

A stratified random sampling survey design was used. Forest type maps (each covering one township) were divided into 81 equal units of approximately 284 acres. The acres of pine and of mixed conifer forest were determined for each unit by dot counting. Nineteen pine type photo plots were selected from those 284 acre units with probability proportional to acres of type. Twenty mixed conifer plots were selected from the units that contained mixed conifer type. A photo plot consisted of the area covered by the appropriate type within each of the units, with a minimum size set of 50 acres.

The plots were photographed in June of 1976. Photo interpreters counted, estimated species and size class, and encircled single and grouped trees on the photograph that had recently died (retained yellow to red foliage) within plot boundaries. Following interpretation, the listings of the dead tree groups obtained from the photographs were stratified by tree species, and a sample of groups to be visited on the ground was randomly selected

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[1/] Joe McBride, Don Dahlsten and Fields Cobb, Jr., of the University of California, cooperated in the planning and execution of the survey.

for ponderosa pine, Jeffrey pine, and white fir in each of the two types. Field crews trained in entomology, pathology, and forestry visited the selected dead tree groups and recorded data on tree species, number, size and year of death, as well as pest species. A pest was listed as a contributor to death of a tree if it was judged abundant enough to have predisposed the trees to insect attack (as was the usual case of pathogens) or killed a weakened tree (in the case of insects and some pathogens). The photo interpretation and ground data were used to calculate estimates of the number of white firs and Jeffrey pines[2/] that died in the Forest during the year prior to photography.

SURVEY RESULTS AND DISCUSSION

An estimated 7312 ± 797 Jeffrey pine and white fir trees died in the survey area during the one year period from June 1975 to June 1976. This is about 0.07 trees per acre. It should be kept in mind that this estimate may be lower than the number that actually died because an unknown number of dead trees were cut and utilized by woodcutters before the photos were taken. Also, the percentage of the tree population that died may be a better measure of loss than trees per acre. Percent tree mortality per year will be included in the later report. But, on the surface, a level of mortality of less than 1/10 tree per acre appears quite low when compared with estimates from other locations which used the same photo and ground methods. Estimates of mortality made on the Stanislaus and Eldorado National Forests in 1973 and 1974 were somewhat higher than this. And, the estimate for Laguna Mountain in 1977 was about 10 times the San Bernardino estimate.

The level of mortality was about twice as high in the pine as in the mixed conifer type. However, the data from 1977 and 1978 are needed before reliable conclusions can be drawn.

The Causes of Mortality. Figure 1 illustrates that a complex containing at least one pathogen and at least one insect species was associated with about 70 percent of the Jeffrey pine and white fir mortality. This situation is similar to that found on other forests surveyed in the past, where most of the mortality was attributed to the combined effects of insects and pathogens.

Pest Complexes of Jeffrey Pine. Two broad pathogen/insect complexes accounted for about 60 percent of the Jeffrey pine mortality, if overlap between the complexes is included (Fig. 2). The first complex, associated with 22 percent of the mortality, was composed of dwarf mistletoe (Arceuthobium campylopodum) and one or more of the following insect species: Jeffrey pine beetle (Dendroctonus jeffreyi), California flatheaded borer (Melanophila californica), pine engraver beetle (Ips. spp.).

[2/] Estimates are given only for white fir and Jeffrey pine since too few groups of other species (most noticeably ponderosa pine) were sampled to give reliable estimates. The level and causes of ponderosa pine mortality will be included in the final report.

The second important pest complex, associated with 21 percent of the mortality of Jeffrey pine, was composed of one or more root pathogens (Fomes annosus, Armillaria mellea, and/or Verticicladiella wagenerii) and one or more of the above insects. A further breakdown of the loss by specific root pathogen species will be made when more data is available. But, it is clear that F. annosus and A. mellea are both important contributors to Jeffrey pine mortality.

The dwarf mistletoe, a root disease and an insect was associated with 18 percent of the Jeffrey pine mortality.

About one-third of the Jeffrey pines were killed by insects in the apparent absence of disease. Injuries, mainly caused by lightning and fire, predisposed about one-half of these to successful attack.

The role of stand and site factors in predisposing the pines to successful invasion by the various pests and pest complexes has not yet been investigated. This will be taken up in the subsequent report.

It is also not yet possible to fully assess the extent of oxidant air pollution damage to the pines. This will be explored in the subsequent report, as well.

Pest Complexes of White Fir. One complex of pests was responsible for more than one-half of the white-fir mortality (Fig. 3). This complex consists of one or both of the root pathogens (F. annosus and/or A. mellea), and the fir engraver (Scolytus ventralis) and/or fir roundheaded borer (Tetropium abietis). It is difficult to judge which of the two root pathogens is contributing most to the death of white fir because F. annosus is especially difficult to detect in true firs, and because both root fungi frequently complement each other. But, it is evident that both of these fungi are playing important roles.

True mistletoe (Phorodendron bolleanum), contributed to the death of some of the root disease infected trees, and at times predisposed the trees to successful insect attack in the apparent absence of a root disease. Less than one-tenth of the white firs were killed by insects in the absence of pathogens.

PEST MANAGEMENT STRATEGIES

A consideration of the behavior of a number of the pest complexes suggests that they are amenable to cultural control. It should be possible to maintain the relatively low level of mortality from certain complexes and perhaps further reduce the effects of others.

The following is a partial list of management strategies that may be useful. Their application to on-the-ground situations will be governed by the specific stand conditions as identified by compartment examination. They should be included in stand prescriptions and carried out as a part of the stand treatments.

1. Borax Stump Treatment. F. annosus was involved in a sizeable proportion of both the fir and pine mortality. Where present, it is considered to play a key role in predisposing the trees to successful insect attack. New infections can be prevented, by sprinkling the cut surface of freshly cut stumps with borax. We recommend that this practice of treating conifer stumps be continued on the forest whenever conifers are cut.

2. Species Conversion. No feasible ways of eradicating F. annosus from an infection center are known, so centers of mortality can be expected to enlarge indefinitely as roots of susceptible trees at the margins of the center are infected.

   The effects of the fungus can be minimized, however, through the use of resistant species. Most hardwoods are resistant to the fungus, and naturally occurring species such as black oak can be successfully grown in openings created by disease. The maintenance of mixed hardwood-conifer stands where they occur can also be used for annosus root disease prevention.

   Species conversion is also a useful tool where dwarf mistletoe is a serious problem. Given the narrow host range of most of the dwarf mistletoes, it is frequently possible to encourage non-host species when thinning or planting. Sugar pine, white fir, incense cedar and the oaks, for example, are all immune or highly resistant to A. campylopodum.

3. Thinning. Thinning can be an important tool to use for minimizing the effects of dwarf mistletoe. The pathogen becomes especially damaging in stands that begin to stagnate. Thinning can accomplish two objectives related to dwarf mistletoe control; cutting the most severely affected trees reduces the overall level of disease, and spacing control allows the trees to grow proportionally faster in height than the parasite moves upward in the tree.

   Thinning is also an effective stand treatment for the prevention of bark beetle outbreaks. This will keep the level of tree mortality caused by insects alone down, and will minimize tree mortality that occurs at times of stress, such as under drought conditions. If the thinning is done early when the stems are small the likelihood of annosus infection of the stumps will be decreased.

4. Overstory Removal. Dwarf mistletoe infected overstory trees present a special threat to young susceptible trees growing nearby. Dwarf mistletoe seeds are forcibly discharged and land in the crowns of understory trees. Infections in the upper crown of young trees are especially damaging. It will be beneficial in the long run to remove selected infected overstory trees in order to prolong the life of the future stand.

Infected overstory trees vary considerably with regard to their threat, however. Young, vigorous, infected trees generally produce more dwarf mistletoe seeds than do old, slow-growing, broomed trees. Where overstory trees are particularly valuable, it may be useful to identify the threatening mistletoe seed producers. This can be done by examining the trees carefully with binoculars, or by seed trapping.

5. Oak Cutting. A. mellea typically infects pines growing in the vicinity of dead oak root systems. The oak root system acts as a food base for the fungus, enabling it to invade nearby conifer roots. Unlike F. annosus that spreads from tree to tree in continuously enlarging centers, the spread of A. mellea is usually limited to the area occupied by the oak root system. Thus, it is considered a less serious disease.

   Cutting oak trees will lead to decay of the roots, infection of nearby conifer roots, and eventually the death of the conifer. Cutting of oaks should be limited in high use areas when the conifers are to be retained. Oaks that have branches that are hazardous to people and facilities might be pruned free of hazards rather than cut.

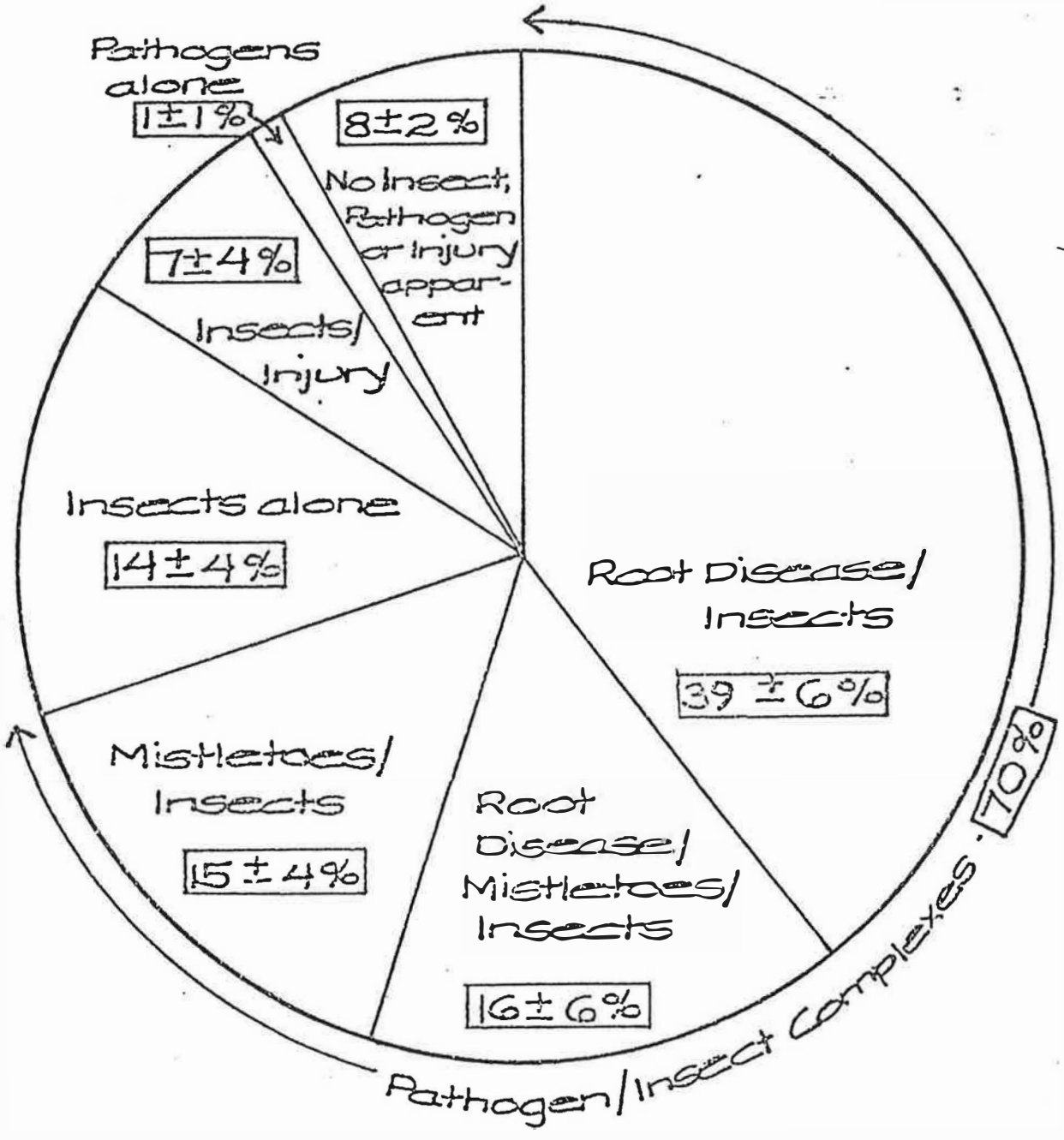

FIGURE 1.

Total Jeffrey Pine and White Fir mortality by pest category.

1976 - San Bernardino National Forest

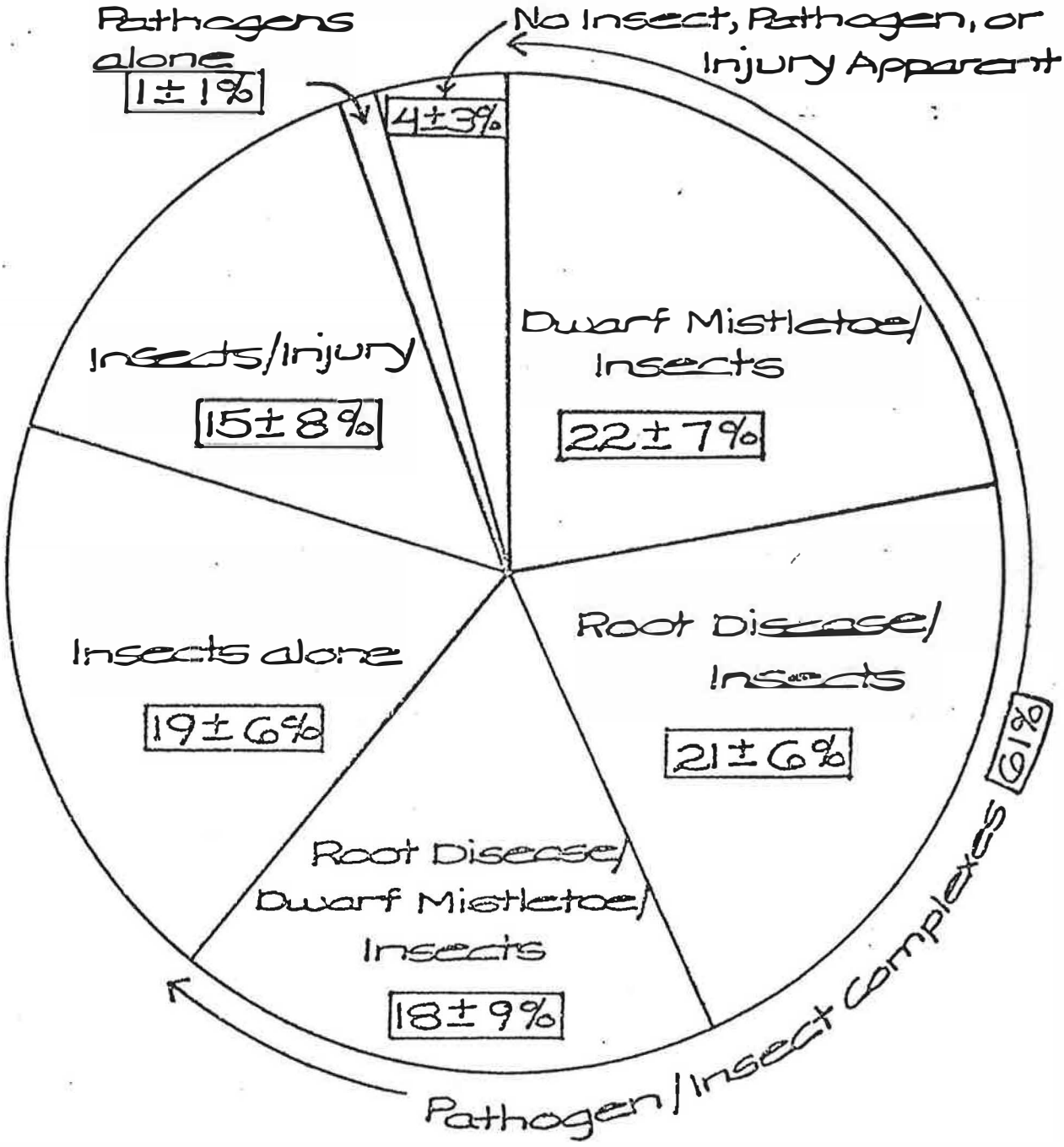

FIGURE 2.

Total Jeffrey Pine mortality by pest category.

1976 - San Bernardino National Forest

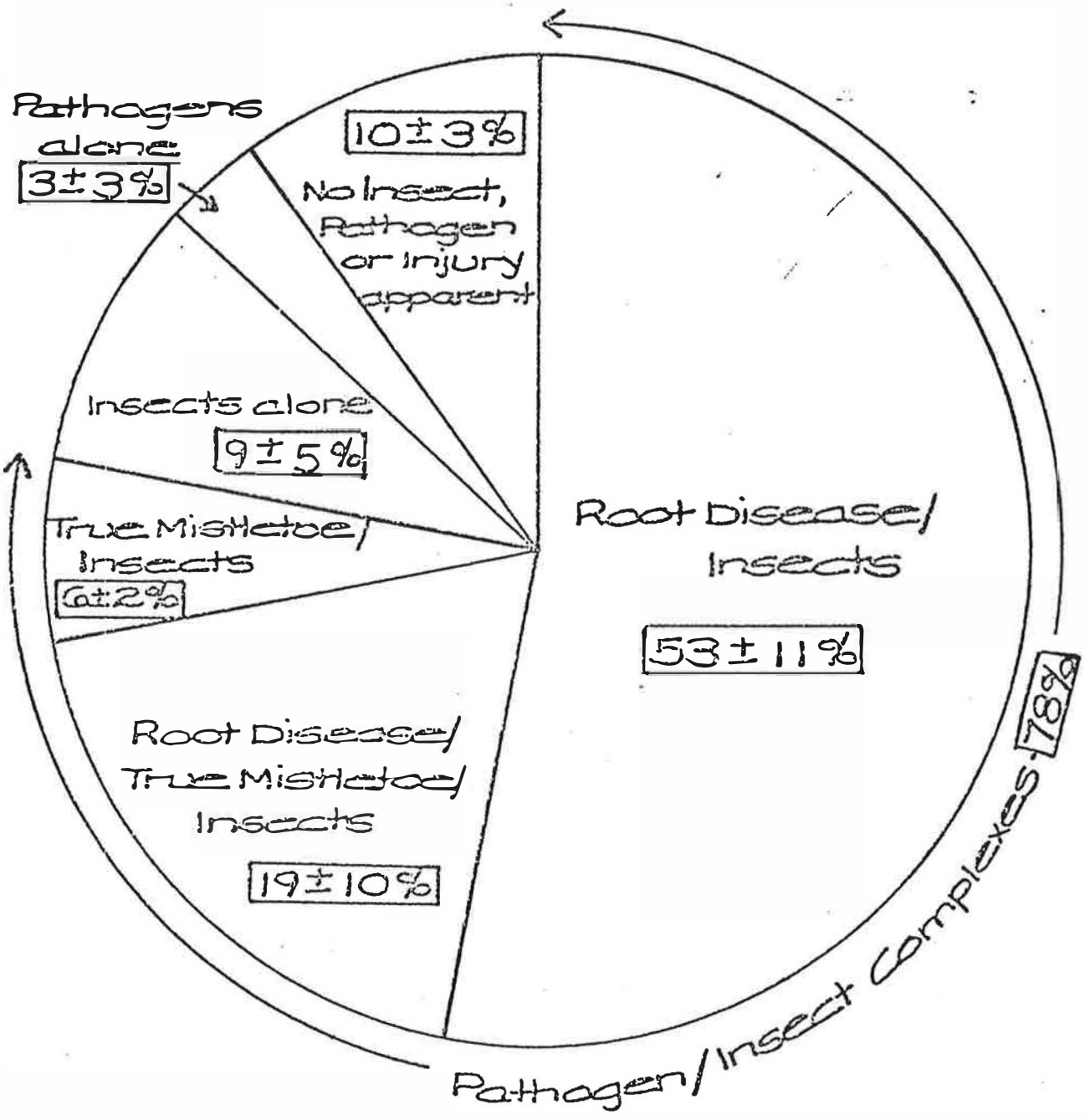

FIGURE 3.

Total White Fir mortality by pest category.

1976 - San Bernardino National Forest

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

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REPLY TO: 5230 Evaluation

March 3, 1978

SUBJECT: A Biological Evaluation of the Level and Causes of Tree Mortality on the San Bernardino N.F. in 1976

TO: Forest Supervisor, San Bernardino N.F.

Enclosed is a copy of a biological evaluation report for your Forest. The purposes of the evaluation were to measure the level of tree mortality, to determine the causes for it, and to assist the Forest in identifying strategies to prevent or reduce the pest-associated tree mortality.

This is an interim report, based on only one year's results (1976) of a three-year evaluation. It includes only the pine and mixed conifer types. And it does not include discussions of stocking densities or oxidant damage. A more detailed evaluation will be written in 1979.

However, we don't expect the major tenets of this report to change. The level of tree mortality and the causes for it do not appear to have changed greatly in 1977. Consequently, the management options discussed in the final report should be similar to those listed in this one. It appears now that cultural treatments aimed at the important pathogen/insect complexes, and integrated with stand management activities, will be more appropriate than maintenance control of the pine bark beetles only.

W. L. Freeman

WILFRED L. FREEMAN, JR., Director
Forest Insect and Disease Management

Enclosure